PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : H04N 7/137 — A1

(11) International Publication Number: WO 89/ 04101

(43) International Publication Date: 5 May 1989 (05.05.89)

(21) International Application Number: PCT/GB88/00871

(22) International Filing Date: 17 October 1988 (17.10.88)

(31) Priority Application Number: 8724789

(32) Priority Date: 19 October 1987 (19.10.87)

(33) Priority Country: GB

(71) Applicant *(for all designated States except US)*: BRITISH TELECOMMUNICATIONS PUBLIC LIMITED COMPANY [GB/GB]; 81 Newgate Street, London EC1A 7AJ (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)* : CARR, Michael, Douglas [GB/GB]; "St Hilda", 137 Kirton Road, Trimley St Martin, Ipswich, Suffolk IP10 0QL (GB). LEANING, Anthony, Richard [GB/GB]; 43 Elmhurst Drive, Ipswich, Suffolk (GB).

(74) Agent: LLOYD, Barry, William; British Telecommunications Public Limited Company , Intellectual Property Unit, 151 Gower Street, London WC1E 6BA (GB).

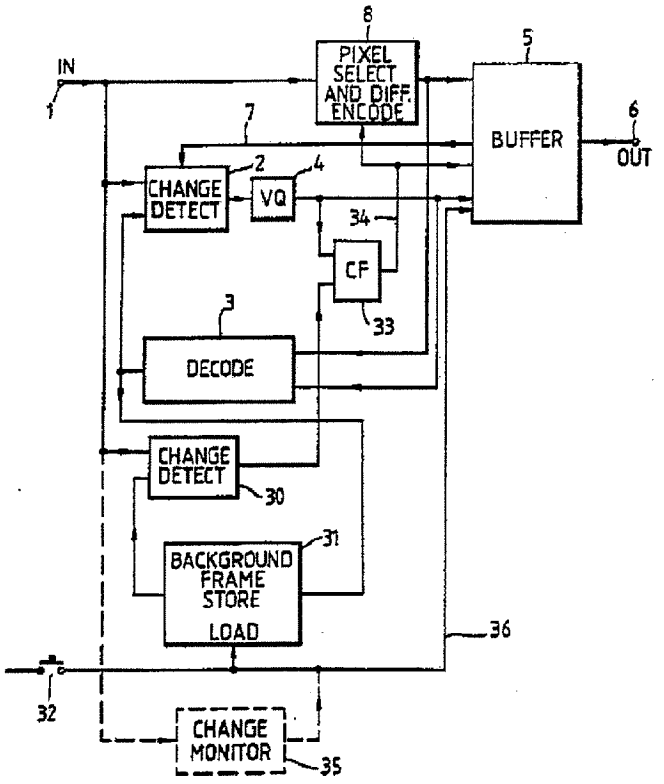
(81) Designated States: AU, DK, FI, JP, NO, US.

Published
With international search report.

(54) Title: SIGNAL CODING

(57) Abstract

The current frame of the picture is compared (2) block-by-block with the previous frame to identify changed picture elements (pixels). The resulting matrix is matched ("vector quantised") (4) to one of a set of standard matrices ("VQ shapes"). Only those pixels flagged by the selected VQ shape are transmitted plus a "VQ shape code". This technique is modified in that the current frame is also compared (30) with a "background" frame stored (31) at the transmitter and at the receiver. Where, for any block, all the pixels flagged by the VQ shape are indicated by the second comparison as being the same as the background, the pixels are not sent - instead a shape code plus a "copy background" instruction is transmitted.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**FR**	France	**ML**	Mali
AU	Australia	**GA**	Gabon	**MR**	Mauritania
BB	Barbados	**GB**	United Kingdom	**MW**	Malawi
BE	Belgium	**HU**	Hungary	**NL**	Netherlands
BG	Bulgaria	**IT**	Italy	**NO**	Norway
BJ	Benin	**JP**	Japan	**RO**	Romania
BR	Brazil	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CF	Central African Republic			**SE**	Sweden
CG	Congo	**KR**	Republic of Korea	**SN**	Senegal
CH	Switzerland	**LI**	Liechtenstein	**SU**	Soviet Union
CM	Cameroon	**LK**	Sri Lanka	**TD**	Chad
DE	Germany, Federal Republic of	**LU**	Luxembourg	**TG**	Togo
DK	Denmark	**MC**	Monaco	**US**	United States of America
FI	Finland	**MG**	Madagascar		

SIGNAL CODING

The present invention relates to coding of video signals, especially using conditional replenishment coding, where information is generally transmitted only in respect of elements of a frame of the picture which have changed relative to a previous frame; the transmitted data being used at a receiver to update a stored version of the picture.

Thus picture elements of each block of an image to be coded are compared with those of the corresponding block of a previously coded image to determine whether the block has changed between the two images; if so, picture element data are generated for output.

Such a system is described in international patent application published under no. WO86/03922, which also proposes that the block be compared with the corresponding block of an earlier (reference) image. If they are deemed to be the same, no picture data are generated - instead, a codeword is produced to indicate that the receiver is to obtain its data from a locally stored replica of the reference image.

According to one aspect of the present invention, there is provided a method of coding an image comprising, for each of a plurality of blocks of an image:

(i) comparing picture elements of the block with those of the corresponding block of a previously coded image to produce a matrix of values each indicating whether the corresponding element is, in accordance with a predetermined criterion, deemed to have changed between the two images;

(ii) matching the matrix to one of a predetermined set of such matrices each of which identifies a region

of the block as being deemed to have changed, and generating a codeword identifying that one matrix of the set;

(iii) comparing picture elements of the block with those of the corresponding block of a reference image composed of blocks from at least one earlier frame to determine whether the block is, in accordance with a predetermined criterion, deemed to have changed between the two images;

(iv) coding for output those elements within the identified region, unless all the elements within the region are identified by comparison step (iii) as being unchanged relative to the reference image, whereupon a codeword indicating this is generated.

In another aspect, the invention provides an apparatus for coding an image comprising,

(i) means for comparing, for each of a plurality of blocks of an image, picture elements of the block with those of the corresponding block of a previously coded image to produce a matrix of values each indicating whether the corresponding element is, in accordance with a predetermined criterion, deemed to have changed between the two images;

(ii) means for matching the matrix to one of a predetermined set of such matrices each of which identifies a region of the block as being deemed to have changed, and generate a codeword identifying that one matrix of the set;

(iii) a store arranged to store a reference image composed of blocks from at least one earlier frame and means for comparing picture elements of the block with those of the corresponding block of the

reference image to determine whether the block is, in accordance with a predetermined criterion, deemed to have changed between the two images;

(iv) means for coding for output those elements within the identified region, unless all the elements within the region are identified by comparison step (iii) as being unchanged relative to the reference image, whereupon a codeword indicating this is generated.

The matching step - often termed vector quantisation - of two-dimensional maps has been proposed previously for picture coding, for example in European patent application serial no. 0239076A, where blocks of transform coefficient blocks are classified.

The present invention, however, further exploits the vector quantisation, in that not only can the classification be used (if desired) to reduce the amount of information that has to be transmitted to indicate which elements have been coded for output, but also the number of occasions on which a "reference" codeword is instead generated are increased.

Some embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

- Figure 1 is a block diagram of a coder according to one embodiment of the invention;
- Figure 2 shows a typical bit map produced by the change detector of the coder of Figure 1;
- Figure 3 illustrates a few standard bit patterns used by the vector quantiser of the coder of Figure 1; and
- Figure 4 is a block diagram of a decoder according to another embodiment of the present invention.

Figure 1 shows a conditional replenishment video coder, where video signals (assumed to be in digital form)

are supplied to an input 1. The current frame of a picture is compared in a change or movement detector 2 with the output of a local decoder 3. The local decoder produces a "previous frame" output which is the same as that produced by a remote decoder; the object of the comparison is to identify those parts of the picture which have changed so that only information concerning those parts needs to be sent to the decoder, to update a stored representation of the frame.

The signals are processed on a block-by-block basis - an 8 x 8 block is assumed - and the change detector 2 therefore produces an 8 x 8 bit map. A typical map is shown in figure 2, where the elements of the block corresponding to picture elements (pixels) which have changed are shown shaded.

In practice, transmission of information concerning only the changed elements involves a significant addressing overhead and therefore it is preferred to match the bit map to one of a limited number - typically forty - of standard shapes (a few are illustrated in figure 3). Since it is preferable to transmit information for an unchanged pixel than to fail to transmit information for a changed pixel, the shape chosen is the smallest (i.e. with the least number of shaded elements) which has a shaded area covering the shaded elements of the bit map. This process is termed vector quantisation (VQ) and is indicated as vector quantizer 4 in figure 1. One transmits, for the block, a VQ number identifying the chosen shape, along with information concerning pixels deemed - in accordance with the chosen shape - to have changed. The output data are combined and buffered in a buffer 5 prior to passage to an output 6. As is conventional in such systems, the buffer is used to smooth variations in the rate at which data are generated (due to

the picture content dependent coding) and interface to a regular transmitted rate and the buffer fullness state used to control the rate of generation (e.g. by varying the change detector thresholds (control line 7)).

The pixels deemed to have changed are coded in an encoder 8 (for example in the manner described in our International patent application PCT/GB88/00709 (publication no. .....) and European patent application no. 88307981.6 (publication no. .....).

Many televised scenes - especially in a videoconference or videotelephone environment - contain moving persons or objects set against a fixed background. Pixels observed as changed by the change detector 2 will relate either to objects which have changed their position (or entered the scene) or to parts of the background uncovered by the object. In the present coder, a second change detector 30 is also shown, which compares the current frame with a reference or background frame stored in a frame store 31. Acquisition of the stored background frame will be discussed further below, but in figure 1 is assumed to have been acquired from the local decoder 3 in response to manual operation of a switch 32 at the commencement of a transmission; a code being transmitted to the receiver to initiate similar action at the remote decoder.

The change detector 30 produces a bit map identifying those pixels of the current frame which are the same as the background.

If this shows that the new image is different from the background for any of the pixels declared as changed by the VQ shape the background information cannot be used and information concerning those pixels is transmitted along with the VQ number.

If, however the changed area as given by the VQ shape covers only pixels which are identified by the detector 30 as being the same as the corresponding pixels of the stored background frame, then the VQ number is accompanied by a reserved codeword indicating "background" and no further information needs to be transmitted for the block in question.

These functions are accomplished in figure 2 by a comparator 33 whose output 34 overrides the operation of the encoder 8.

Figure 4 shows a decoder. An input processor 40 receives the coded input signals. The background frame is stored in a background store 41. In normal operation, the processor 40 uses the pixel information received to update via line 42 the contents of a frame store 43, using the received VQ numbers via line 44 to control the frame store addressing. When, however, it receives the reserved "background" codeword (via line 45), it recovers the relevant pixels (identified by the VQ number) from the background store 41 and enters then into the frame store 43. This is illustrated schematically by a changeover switch 46. The frame store 43 is read out (by output control means 47) to produce the received video at an output 48. As in the coder, the background store 41 is loaded from the decoded image in store 43 when a 'load background' instruction is received (line 49).

Note that the local decoder 3 of Figure 1 can be of the same construction as the decoder of Figure 4, although, of course, in practice the local decoder would use the background store 31 rather than contain one of its own.

The change detectors 2,30 can in principle be any conventionally used, or may both be as described in our above-mentioned patent applications. The vector

quantiser 4 can again be a known device. One possibility is that described in our International patent application no. PCT/GB87/00816 (publication no. WO88/04084) and European patent application no. 8627787 (publication no. 0272794).

Simpler but cruder, another option is to convert the 8x8 matrix to a 4x4 matrix by creating each 'new' element as an OR function of four 'old' elements; this reduces the number of elements in the matrix to a size (16) which can be used to address a look-up table - in the form of a 64 Kbyte read only memory in which the appropriate VQ numbers are stored.

The background scene may be 'frozen' manually at the commencement of a transmission. It may, but does not have to, consist solely of a fixed background. For example it may include seated figures (thereby covering the situation where a person momentarily passes his hand over his face if the face forms part of the "background", the face does not have to be retransmitted).

It may be desirable to include provision for updating the background. For example, the incoming video could be monitored at the coder (by a unit 35 shown dotted in Figure 1) and parts of the picture which differ from the original background but have remained unchanged for a predetermined period of time inserted into the frame store, a signal being sent (via line 36) to the decoder to instruct it to do likewise.

An alternative method of updating the background store abandons any attempt at identifying genuine background, but instead forms a reference image which is a composite of blocks taken from preceding images over a period. Each frame period, data for a few (e.g. eight) selected blocks scattered over the image area is entered into the background stores, the block selection being such that

different blocks are selected from each frame until the whole image area has been covered. Assuming 1024 blocks per frame at 25 frames per second, this represents a period of approximately 40 seconds. The blocks could be loaded from the frame store 43 of the decoder, and a corresponding store in the local decoder 3, the change monitor then being replaced by a simple address generator 35 to select the appropriate blocks. Clearly, this is less effective, in that some blocks of the reference image will not represent background material, but a significant coding advantage is still obtained, and it has the merit of simplicity.

A variation of this approach provides that data for selected blocks, instead of being drawn from the decoded image, are actually transmitted - i.e. transmission of the whole block is forced even if only a part, or none, of it is indicated by the detector 2 and quantiser 4 as moving. In this case, the frame stores 31, 41 take their input from the input 1 and processor 40 respectively. This also has the benefit of ensuring that transmission errors on blocks which rarely change do not persist in the decoded image.

CLAIMS

1. A method of coding an image comprising, for each of a plurality of blocks of an image:

(i) comparing picture elements of the block with those of the corresponding block of a previously coded image to produce a matrix of values each indicating whether the corresponding element is, in accordance with a predetermined criterion, deemed to have changed between the two images;

(ii) matching the matrix to one of a predetermined set of such matrices each of which identifies a region of the block as being deemed to have changed, and generating a codeword identifying that one matrix of the set;

(iii) comparing picture elements of the block with those of the corresponding block of a reference image composed of blocks from at least one earlier frame to determine whether the block is, in accordance with a predetermined criterion, deemed to have changed between the two images;

(iv) coding for output those elements within the identified region, unless all the elements within the region are identified by comparison step (iii) as being unchanged relative to the reference image, whereupon a codeword indicating this is generated.

2. A method according to claim 1 in which, in the coding of the elements within the identified region, at least some of the elements are coded as the difference between that element and a predicted value for that element derived from one or more previously coded elements

of the block, the sequence of coding of the elements being dependent on the orientation of the identified region.

3. An apparatus for coding an image comprising,

(i) means for comparing, for each of a plurality of blocks of an image, picture elements of the block with those of the corresponding block of a previously coded image to produce a matrix of values each indicating whether the corresponding element is, in accordance with a predetermined criterion, deemed to have changed between the two images;

(ii) means for matching the matrix to one of a predetermined set of such matrices each of which identifies a region of the block as being deemed to have changed, and generate a codeword identifying that one matrix of the set;

(iii) a store arranged to store a reference image composed of blocks from at least one earlier frame and means for comparing picture elements of the block with those of the corresponding block of the reference image to determine whether the block is, in accordance with a predetermined criterion, deemed to have changed between the two images;

(iv) means for coding for output those elements within the identified region, unless all the elements within the region are identified by comparison step (iii) as being unchanged relative to the reference image, whereupon a codeword indicating this is generated.

4. An apparatus according to claim 3, including means for comparing successive images to identify parts of

the image which have remained unchanged for a predetermined period of time, and in the event of such parts being identified, to:

(a) update the stored reference image; and

(b) code for output data indicating which parts of the reference image have been thus updated.

5. An apparatus according to claim 3, including means arranged in operation to effect periodic replacement of a minority of the blocks of the reference image stored in the store by the corresponding blocks of a recent image, the blocks being differently selected for successive replacements such that the store always contains a composite image made up of blocks from a plurality of frames of the image being coded.

6. A decoder for use with the coder of claim 3 or 5, comprising:

(a) a frame store for storing a received image;

(b) a second frame store;

(c) control means responsive to received data to update the contents of the second frame store using the received data and responsive to a received codeword to update the second frame store with information from the first frame store;

(d) means for repetitively reading the contents of the second frame store to produce a video output signal.

Fig.1.

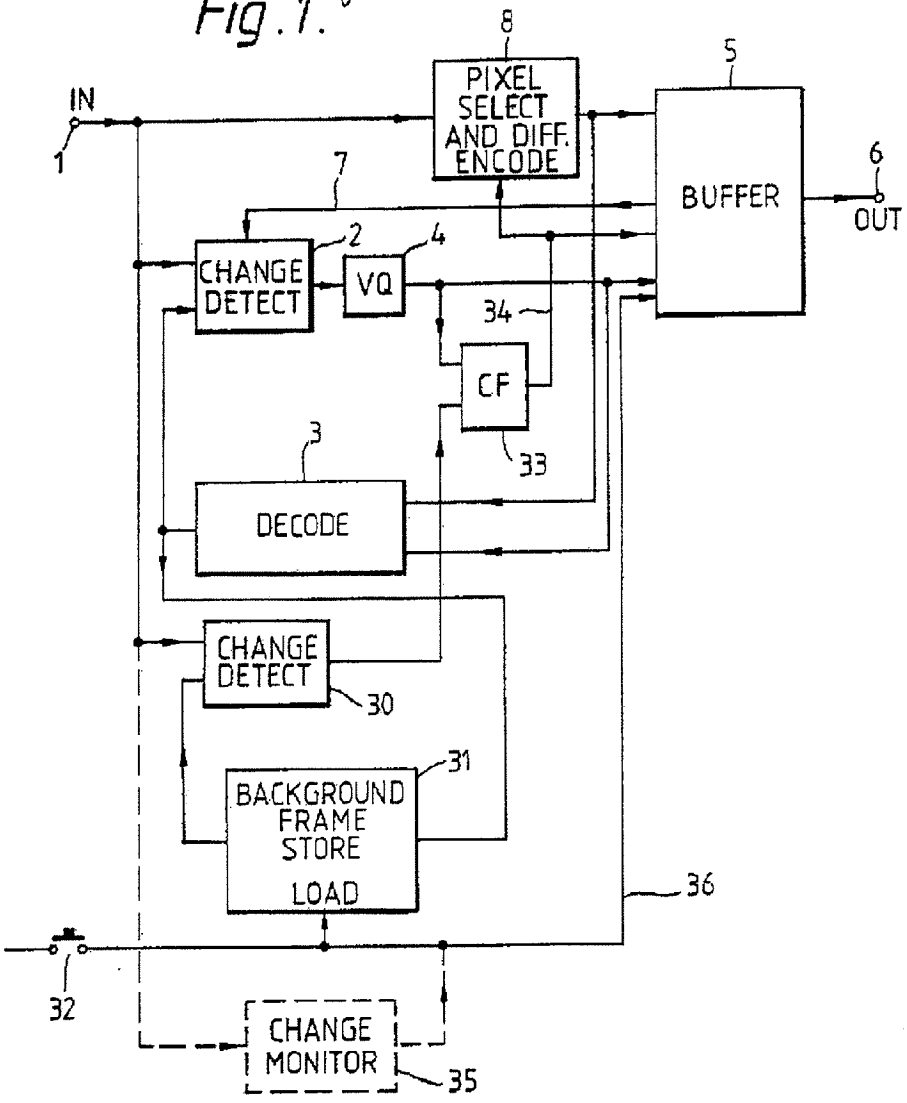

IN
1
PIXEL SELECT AND DIFF. ENCODE
8
5
BUFFER
6
OUT
7
CHANGE DETECT
2
VQ
4
34
CF
33
3
DECODE
CHANGE DETECT
30
BACKGROUND FRAME STORE
LOAD
31
36
32
CHANGE MONITOR
35

Fig.2.

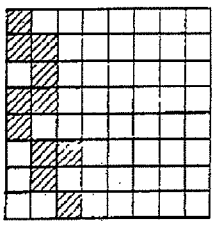
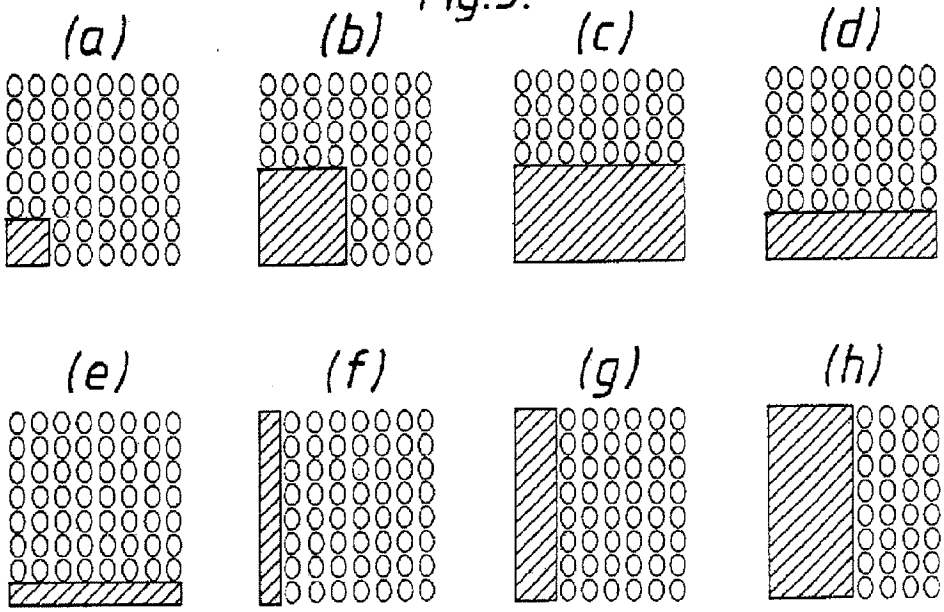


Fig.3.


(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)

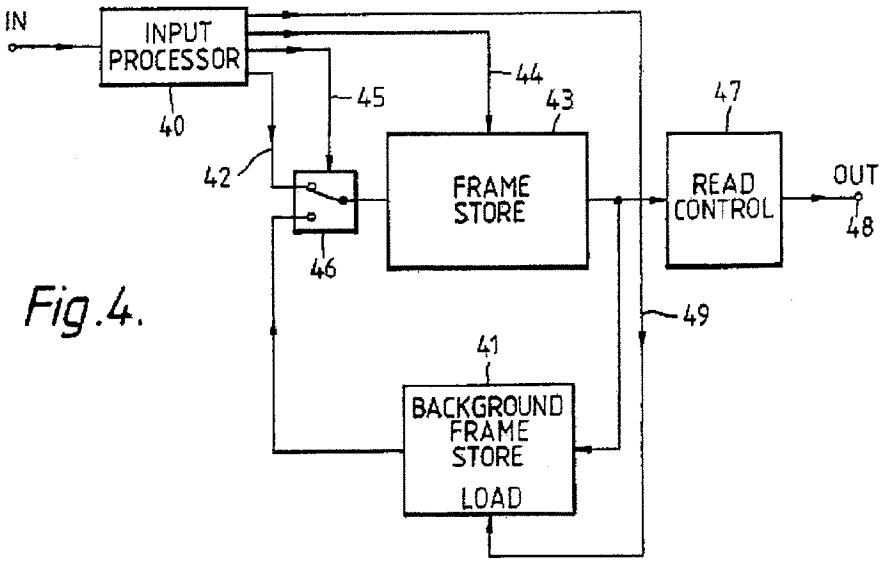

IN
INPUT PROCESSOR
40
45
44
43
47
42
FRAME STORE
READ CONTROL
OUT
48
46
49
41
BACKGROUND FRAME STORE LOAD

Fig.4.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 88/00871

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [5]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: H 04 N 7/137

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	H 04 N

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	WO, A, 86/03922 (VALTION TEKNILLINEN TUTKIMUS-KESKUS) 3 July 1986, see page 4, line 5 - page 7, line 22	1,3,6
A	(cited in the application)	2,4
Y	EP, A, 0239076 (KOKUSAI DENSHIN DENWA CO.) 30 September 1987, see column 7, lines 6-48; column 9, lines 7-39; column 10, line 24 - column 13, line 4; column 16, line 16 - column 18, line 12	1,3,6
A		2
A	GB, A, 2003001 (D.E. PEARSON et al.) 28 February 1979, see abstract; page 4, lines 87-127	1-3

./.

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
16th December 1988	10. 01. 89
International Searching Authority: EUROPEAN PATENT OFFICE	Signature of Authorized Officer: M. VAN MOL

Form PCT/ISA/210 (second sheet) (January 1985)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS, 22nd-25th June 1986, Toronto, vol. 1 IEEE (New-York, US) J. Guichard et al.: "Intra- and inter frame transform coding for moving pictures transmission" pages 12.7.1 - 12.7.4, see page 12.7.2, right-hand column, line 25 - page 12.7.3, right-hand column, line 16; table 2 --	1-3
A	US, A, 4591909 (HIDEO KURODA et al.) 27 May 1986, see abstract; column 1, line 55 - column 2, line 59; column 3, lines 22-25; column 13, lines 32-68; column 16, lines 27-38; figure 1	1-6

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 8800871

SA 24886

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 30/12/88
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A- 8603922	03-07-86	AU-A- 5192886	22-07-86
		JP-T- 62501532	18-06-87
		EP-A- 0245253	19-11-87
		US-A- 4717957	05-01-88
EP-A- 0239076	30-09-87	JP-A- 62222783	30-09-87
		US-A- 4734767	29-03-88
GB-A- 2003001	28-02-79	None	
US-A- 4591909	27-05-86	EP-A,B 0123616	31-10-84
		JP-A- 59194588	05-11-84
		JP-A- 59194589	05-11-84